RESPIRATORY SYSTEM

FUNCTIONS OF THE RESPIRATORY SYSTEM

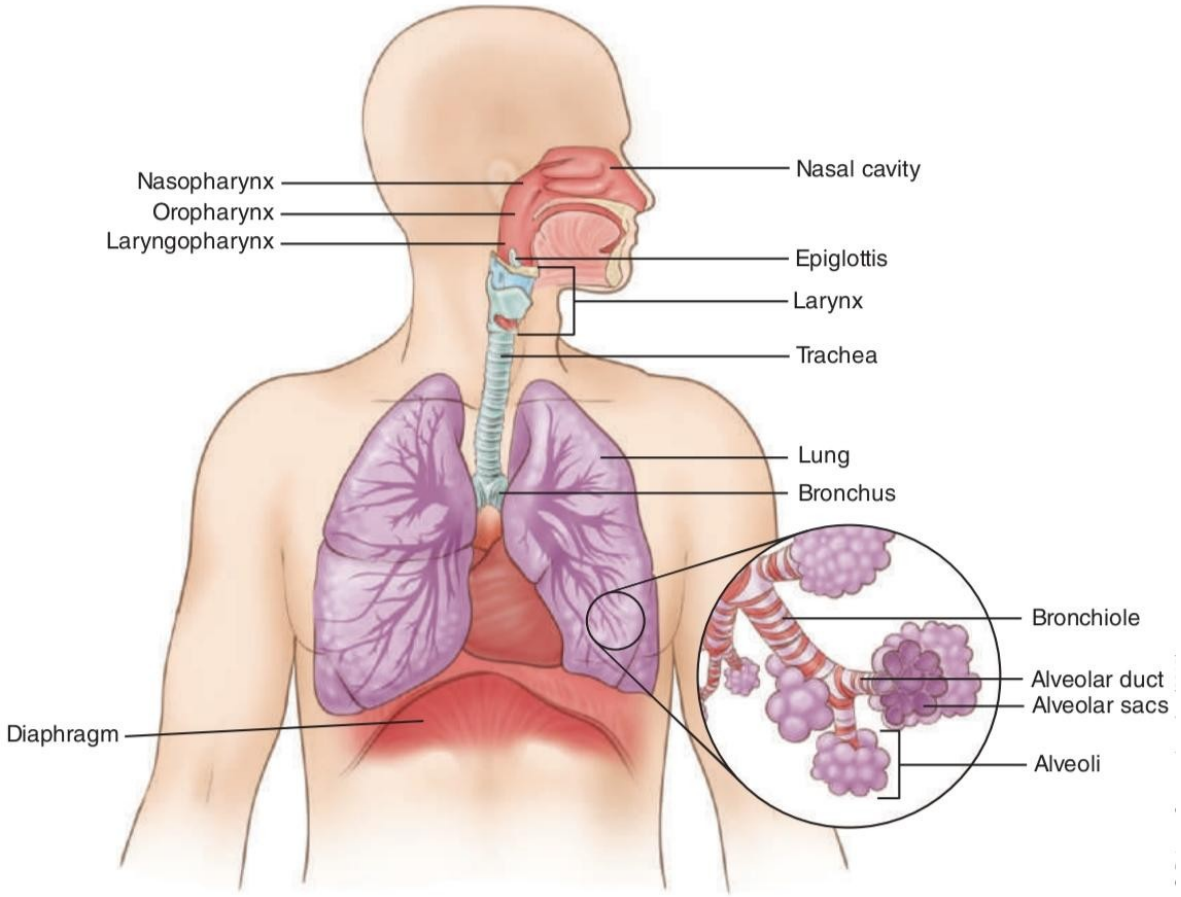
The functions of the respiratory system are to:

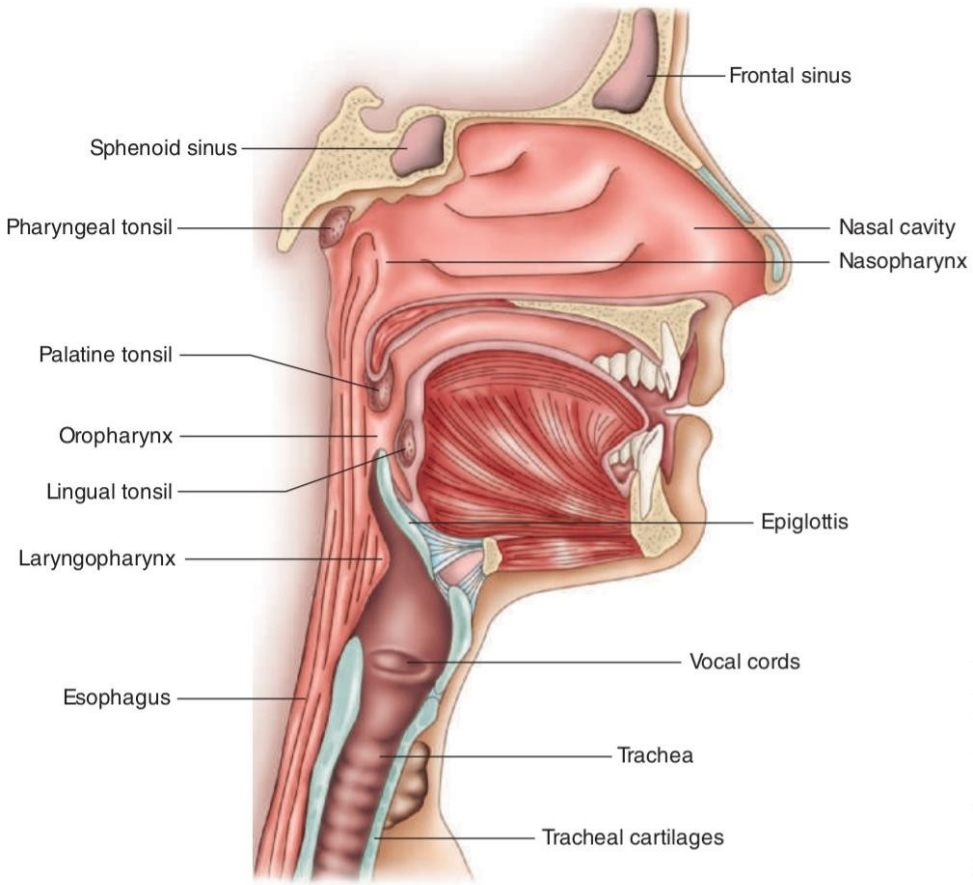
- Deliver air to the lungs.
- Convey oxygen from the inhaled air to the blood for delivery to the body cells.
- Expel the waste products (carbon dioxide and a small amount of water) returned to the lungs by the blood through exhalation.
- Produce the airflow through the larynx that makes speech possible.

STRUCTURES OF THE RESPIRATORY SYSTEM

The **respiratory system** supplies the blood with oxygen for transportation to the cells in all parts of the body. *Oxygen* is vital to the survival and function of these cells. The respiratory system also removes carbon dioxide and some water waste from the body.

- The **upper respiratory tract** consists of the nose (nostrils), mouth, pharynx, epiglottis, larynx, and trachea.
- The **lower respiratory tract** consists of the bronchial tree and lungs. These structures are located within and protected by the **thoracic cavity**, or **thorax**, also known as the **rib cage.**
- The upper respiratory tract and the bronchial tree of the lower respiratory tract are sometimes referred to as the **airway.**


Nasopharynx
Oropharynx
Laryngopharynx
Nasal cavity
Epiglottis
Larynx
Trachea
Lung
Bronchus
Bronchiole
Alveolar duct
Alveolar sacs
Alveoli
Diaphragm


Frontal sinus
Sphenoid sinus
Pharyngeal tonsil
Nasal cavity
Nasopharynx
Palatine tonsil
Oropharynx
Lingual tonsil
Epiglottis
Laryngopharynx
Vocal cords
Esophagus
Trachea
Tracheal cartilages

The Nose

Air enters the body through the **nose** and passes through the **nasal cavity**, which is the interior portion of the nose.

- The nostrils are the external openings of the nose.
- The nasal septum is a wall of cartilage that divides the nose into two equal sections. (A *septum* is a wall that separates two chambers.)
- Cilia the thin hairs located just inside the nostrils, filter incoming air to remove debris. (The *nostrils* are the external openings of the nose.)
- Mucous membranes line the nose.
- Mucus is a slippery secretion produced by the mucous membranes that protects and lubricates these tissues. In the nose, mucus helps moisten, warm, and filter the air as it enters.

  *Mucous is the name of the tissue; mucus is the secretion that flows from the tissue.

- The olfactory receptors are nerve endings that act as the receptors for the sense of smell. They are also important to the sense of taste. These receptors are located in the mucous membrane in the upper part of the nasal cavity.

The Tonsils

They help protect the body from infection coming through the nose or the mouth.

The tonsils, also called the *palatine tonsils*, are located at the back of the mouth.

The adenoids, also called the *nasopharyngeal tonsils*, are higher up, behind the nose and the roof of the mouth.

The Paranasal Sinuses

The paranasal sinuses, which are air-filled cavities lined with mucous membrane, are located in the bones of the skull. * (para- means near, nas means nose, and -al means pertaining to)

A *sinus* can be a sac or cavity in any organ or tissue; however, the term sinus most commonly refers to the paranasal sinuses.

The functions of these sinuses are

(1) to make the bones of the skull lighter,

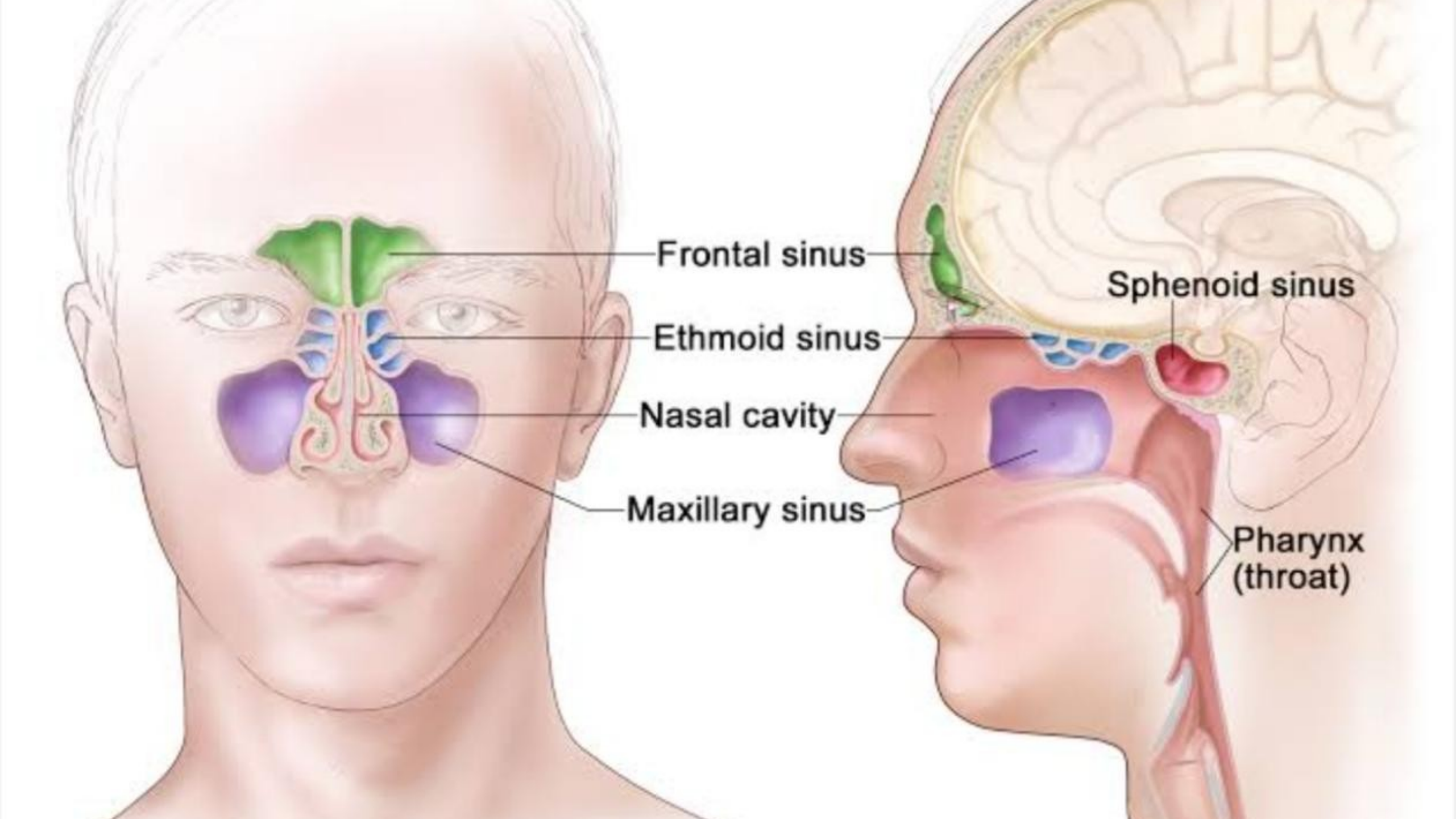
(2) to help produce sound by giving resonance to the voice,

(3) to produce mucus to provide lubrication for the tissues of the nasal cavity.

The Paranasal Sinuses

The sinuses are connected to the nasal cavity via short ducts. The four pairs of paranasal sinuses are located on either side of the nose and are named for the bones in which they are located.

- The **frontal sinuses** are located in the frontal bone just above the eyebrows.
- The **sphenoid sinuses**, which are located in the sphenoid bone behind the eye and under the pituitary gland, are close to the optic nerves, and an infection here can damage
- The **maxillary sinuses**, which are the largest of the paranasal sinuses, are located in the maxillary bones under the eyes.
- The **ethmoid sinuses**, which are located in the ethmoid bones between the nose and the eyes, are irregularly shaped air cells that are separated from the orbital (eye) cavity by only a thin layer of bone.

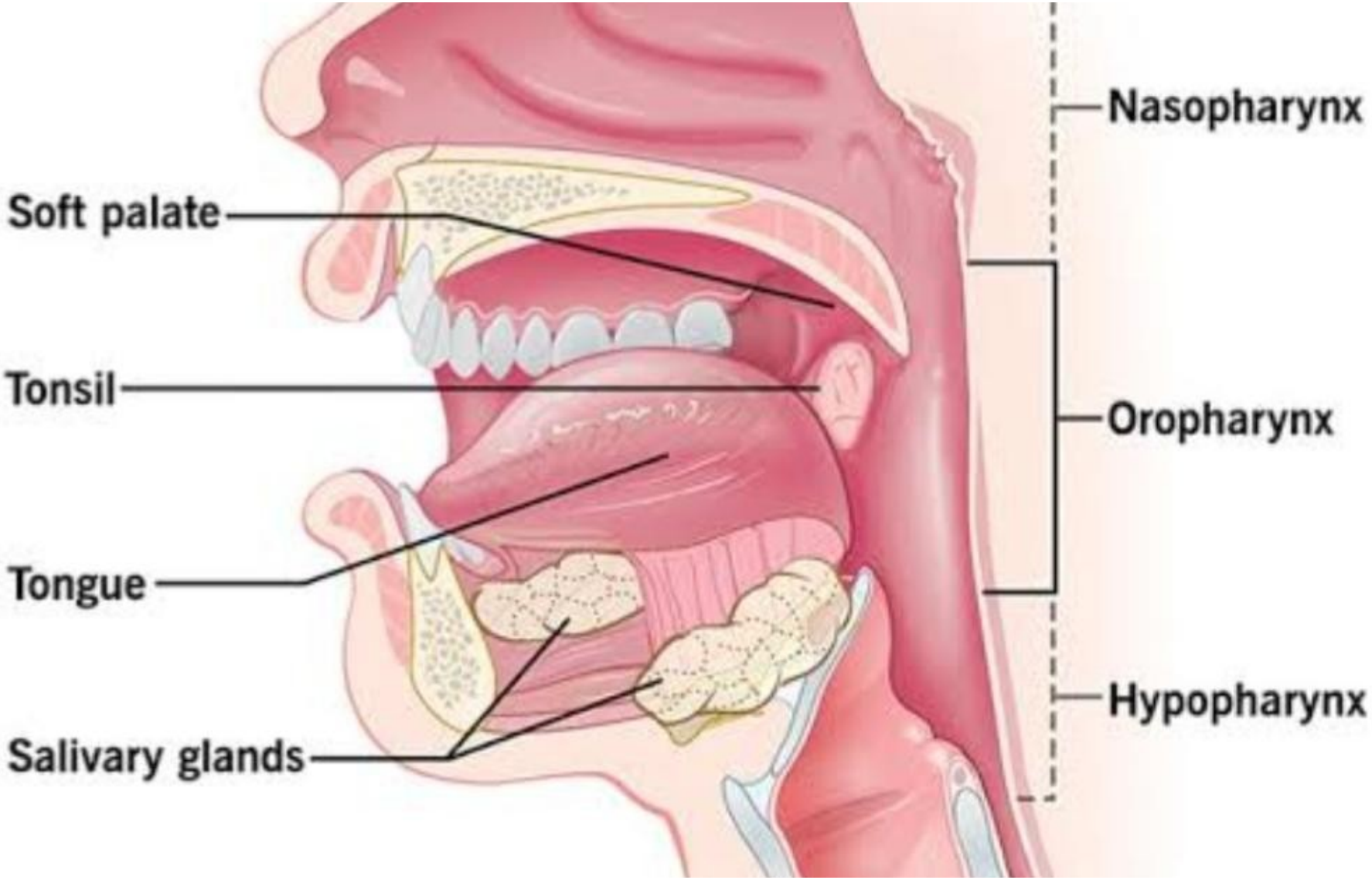

Frontal sinus
Ethmoid sinus
Nasal cavity
Maxillary sinus
Sphenoid sinus
Pharynx
(throat)

The Pharynx

The pharynx, which is commonly known as the throat, receives the air after it passes through the nose or mouth, as well as food.

The pharynx is made up of three divisions

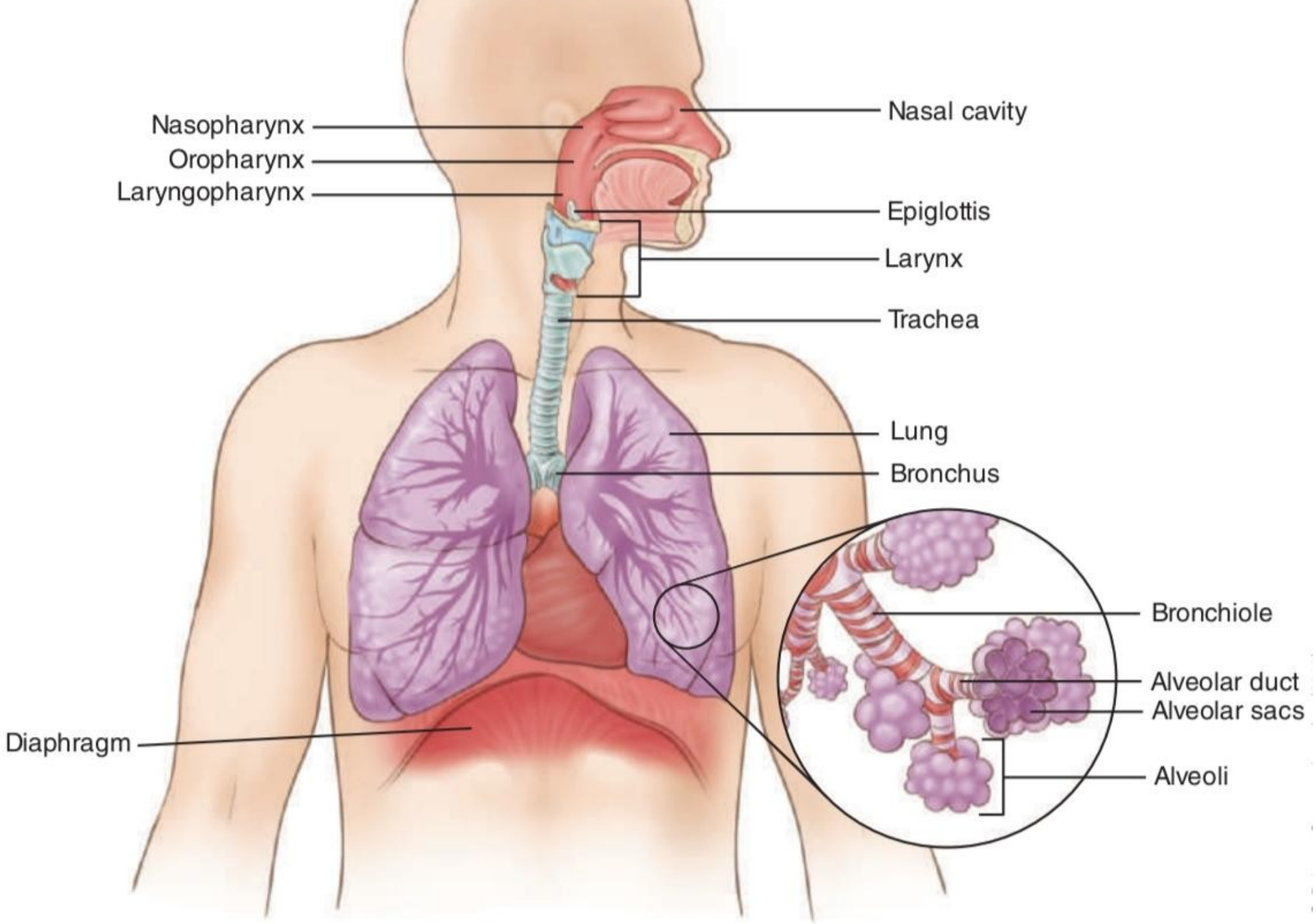
- The **nasopharynx**, which is the first division, is posterior to the nasal cavity and continues downward to behind the mouth. *(nas/o means nose, and -pharynx means throat)
- The **oropharynx**, which is the second division, is the portion that is visible when looking into the mouth. *(or/o means mouth, and -pharynx means throat)
- The **laryngopharynx**, which is the third division, is also shared by both the respiratory and digestive systems. *(laryng/o means larynx, and -pharynx means throat)


Nasopharynx
Soft palate
Tonsil
Oropharynx
Tongue
Hypopharynx
Salivary glands

Larynx

The larynx, also known as **the voice box**, is a triangular chamber located between the pharynx and the trachea.

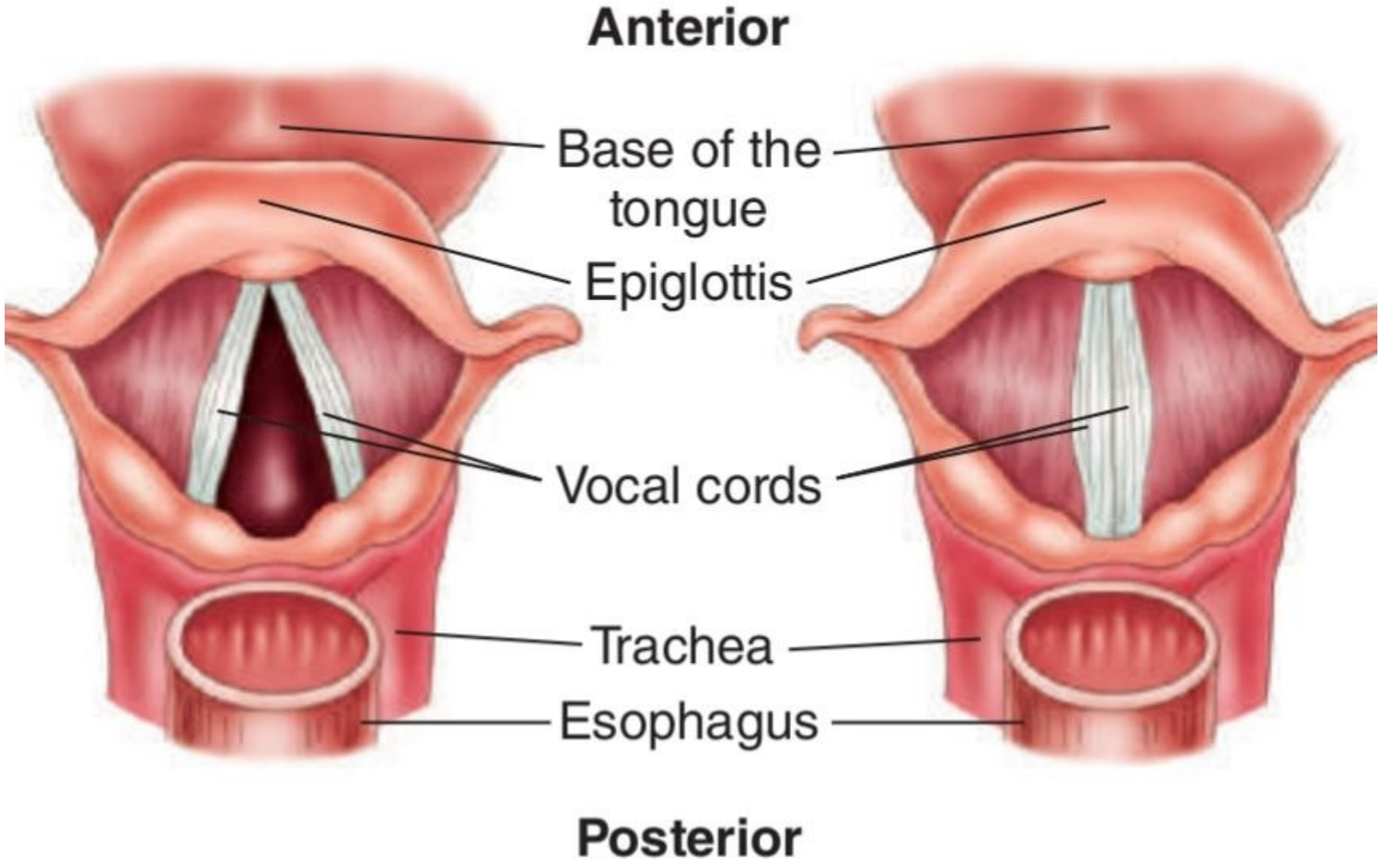
- The larynx is protected and supported by a series of nine separate cartilages. The thyroid cartilage is the largest, and when enlarged it projects from the front of the throat and is commonly known as **the Adam’s apple**.
- The larynx contains the vocal cords. During breathing, the cords are separated to let air pass. During speech, they close together, and sound is produced as air is expelled from the lungs, causing the cords to vibrate against each other.


Nasopharynx
Oropharynx
Laryngopharynx
Nasal cavity
Epiglottis
Larynx
Trachea
Lung
Bronchus
Bronchiole
Alveolar duct
Alveolar sacs
Alveoli
Diaphragm

Protective Swallowing Mechanisms

The respiratory and digestive systems share part of the pharynx. During swallowing, there is the risk of a blocked airway or aspiration pneumonia caused by food or water going into the trachea and entering the lungs, instead of going into the esophagus.

- Two protective mechanisms act automatically during swallowing to ensure that only air goes into the lungs:
- The soft palate, which is the muscular posterior portion of the roof of the mouth, moves up and backward during swallowing to close off the nasopharynx. This prevents food or liquid from going up into the nose.
- At the same time, the epiglottis, which is a lid-like structure located at the base of the tongue, swings downward and closes off the laryngopharynx so that food does not enter the trachea



View of the larynx and vocal cords from above.

Shown on the left, the vocal cords are open during breathing. On the right, the vocal cords vibrate together during speech.

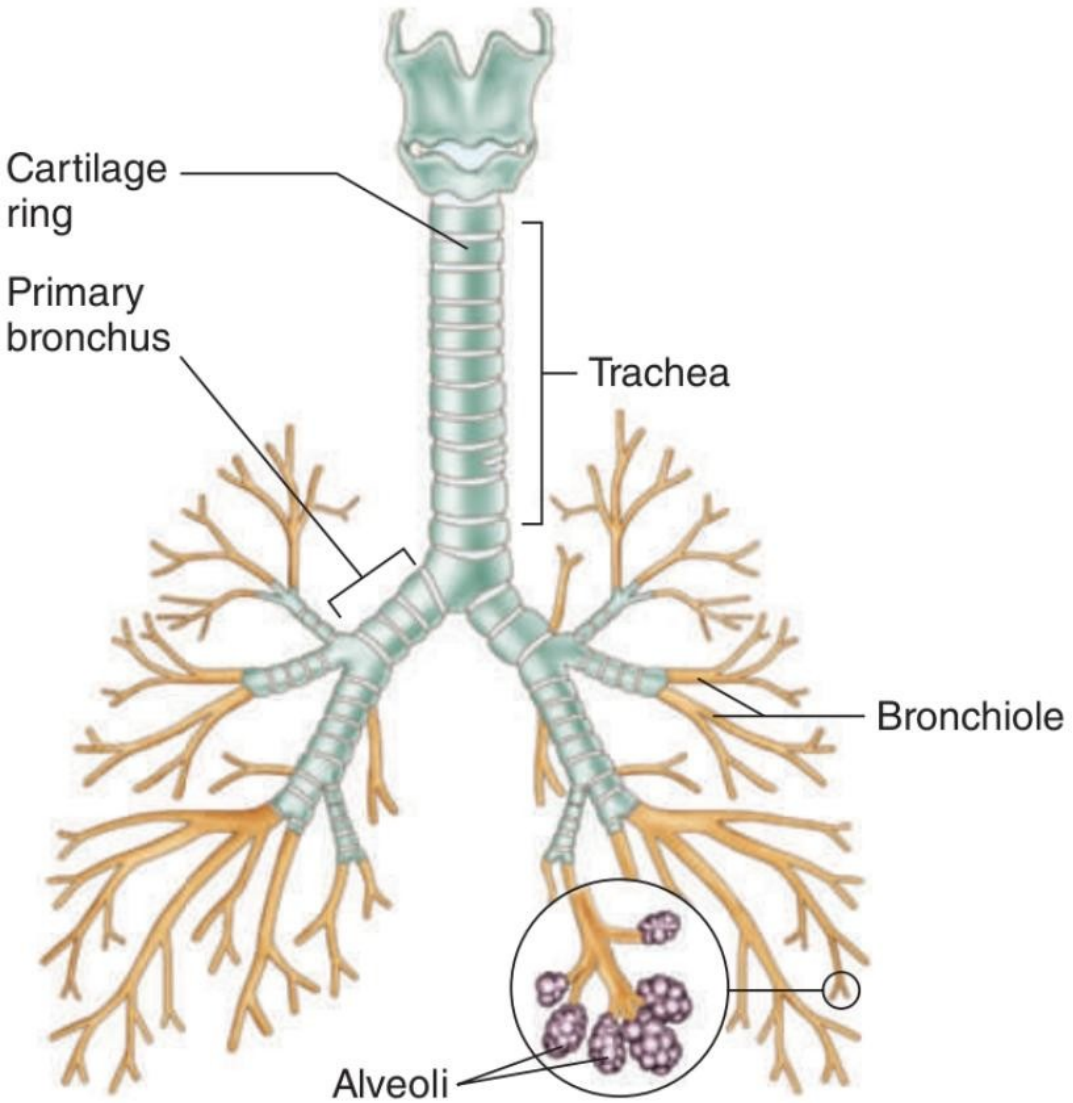
The Trachea

- The role of the trachea is to transport air to and from the lungs. This tube, which is commonly known as the **windpipe**, is located directly in front of the esophagus.
- The trachea is held open by a series of flexible C-shaped cartilage rings that make it possible for the trachea to compress so that food can pass down the esophagus.

The Bronchi

The bronchi are two large tubes, also known as *primary bronchi*, which branch out from the trachea and convey air into the two lungs. Because of the similarity of these structures to an inverted tree, this is referred to as the *bronchial tree*.

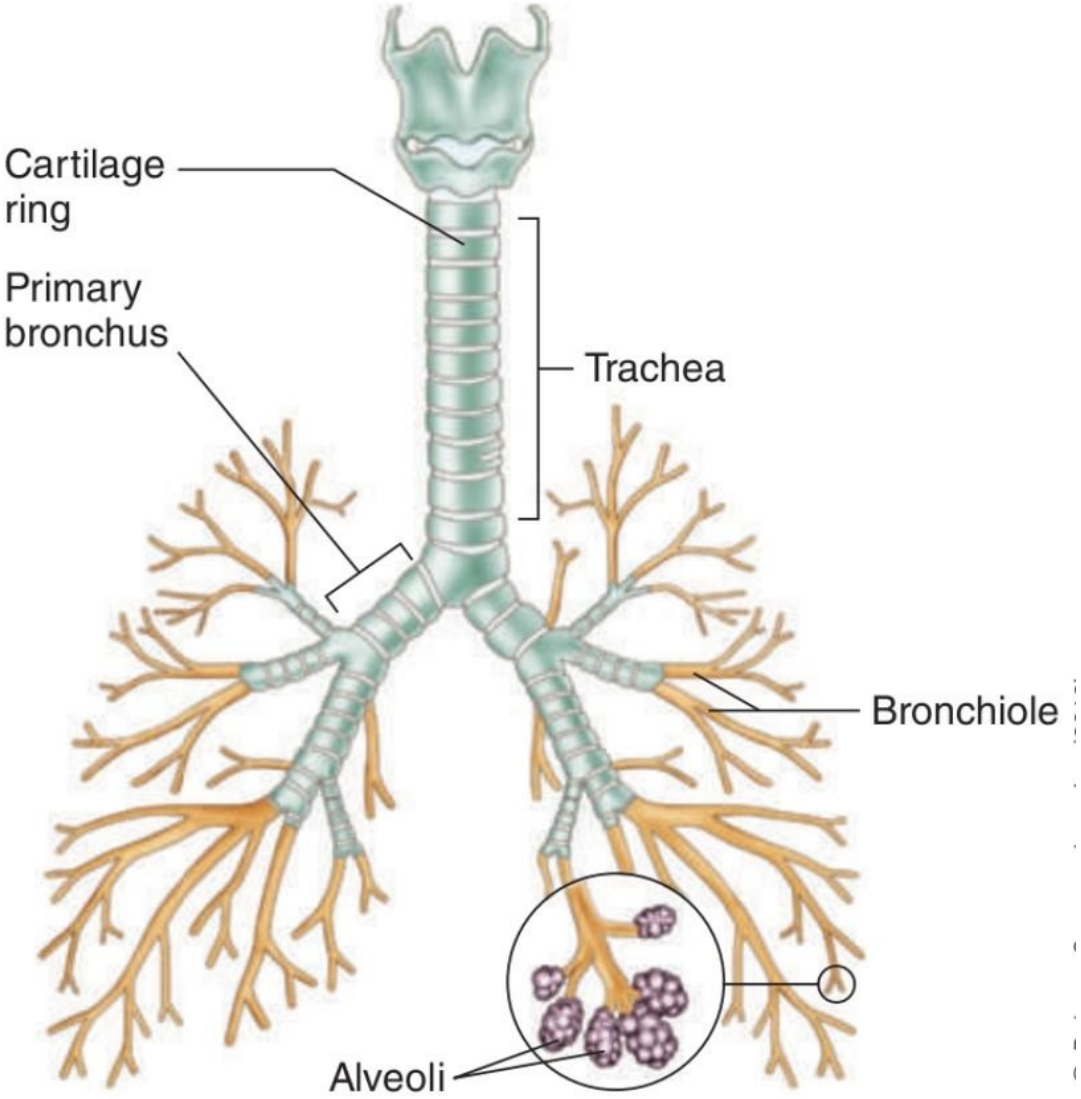
- Within the lung, each primary bronchus divides and subdivides into increasingly smaller bronchioles, which are the smallest branches of the bronchi.



The Alveoli

Alveoli, also known as air sacs, are the very small grapelike clusters found at the end of each bronchiole. The alveoli are where the exchange of oxygen and carbon dioxide takes place. Each lung contains millions of alveoli.

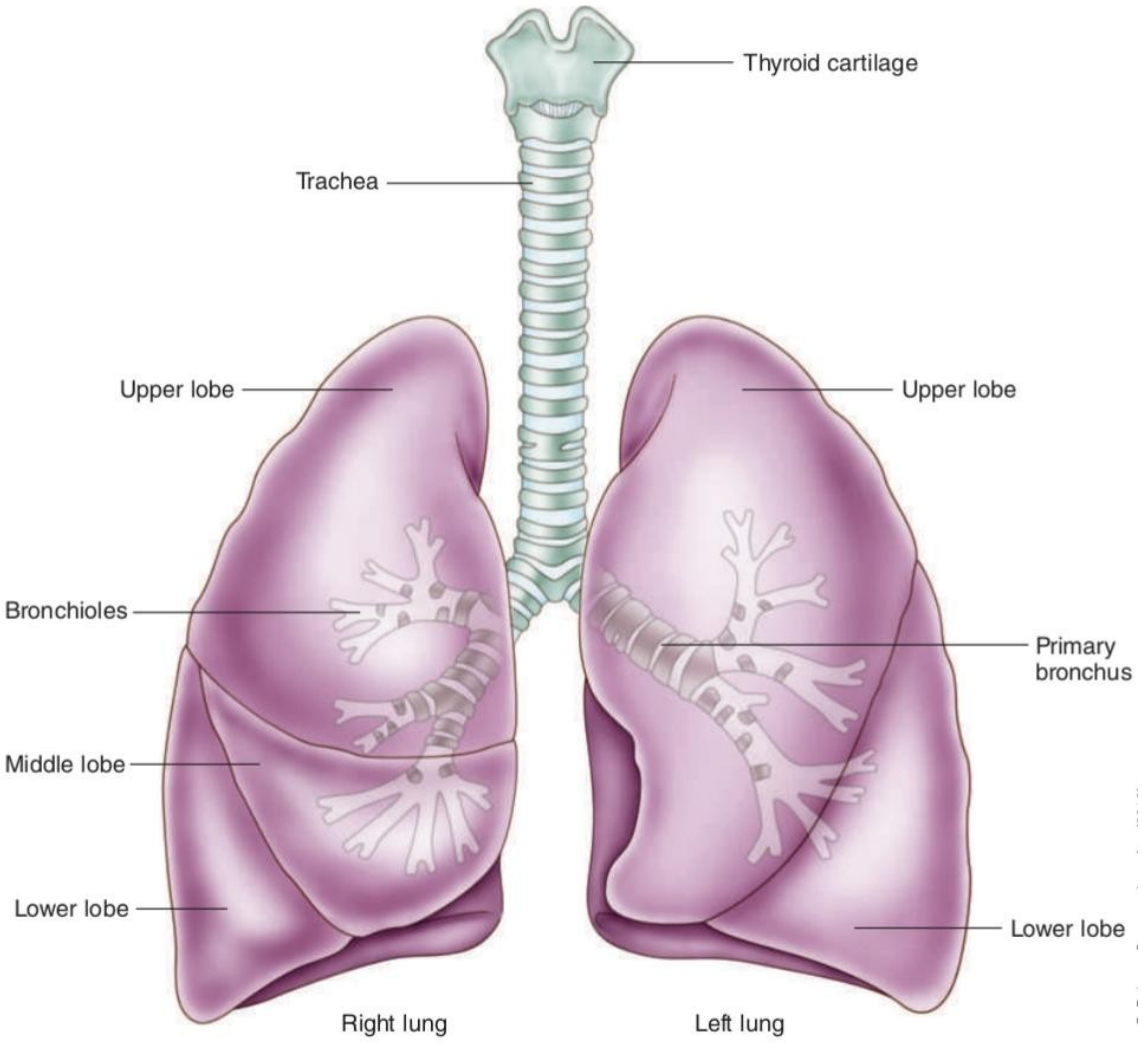
- During respiration, the alveoli are filled with air from the bronchioles.
- A network of microscopic pulmonary capillaries surrounds the alveoli. Pulmonary means relating to or affecting the lungs.
- The exchange of oxygen and carbon dioxide between the air inside the alveoli and the blood in the pulmonary capillaries occurs through the thin, elastic walls of the alveoli.
- The alveoli produce a detergent-like substance, known as a surfactant, which reduces the surface tension of the fluid in the lungs. This makes the alveoli more stable so they do not collapse when an individual exhales. Premature



The Lungs

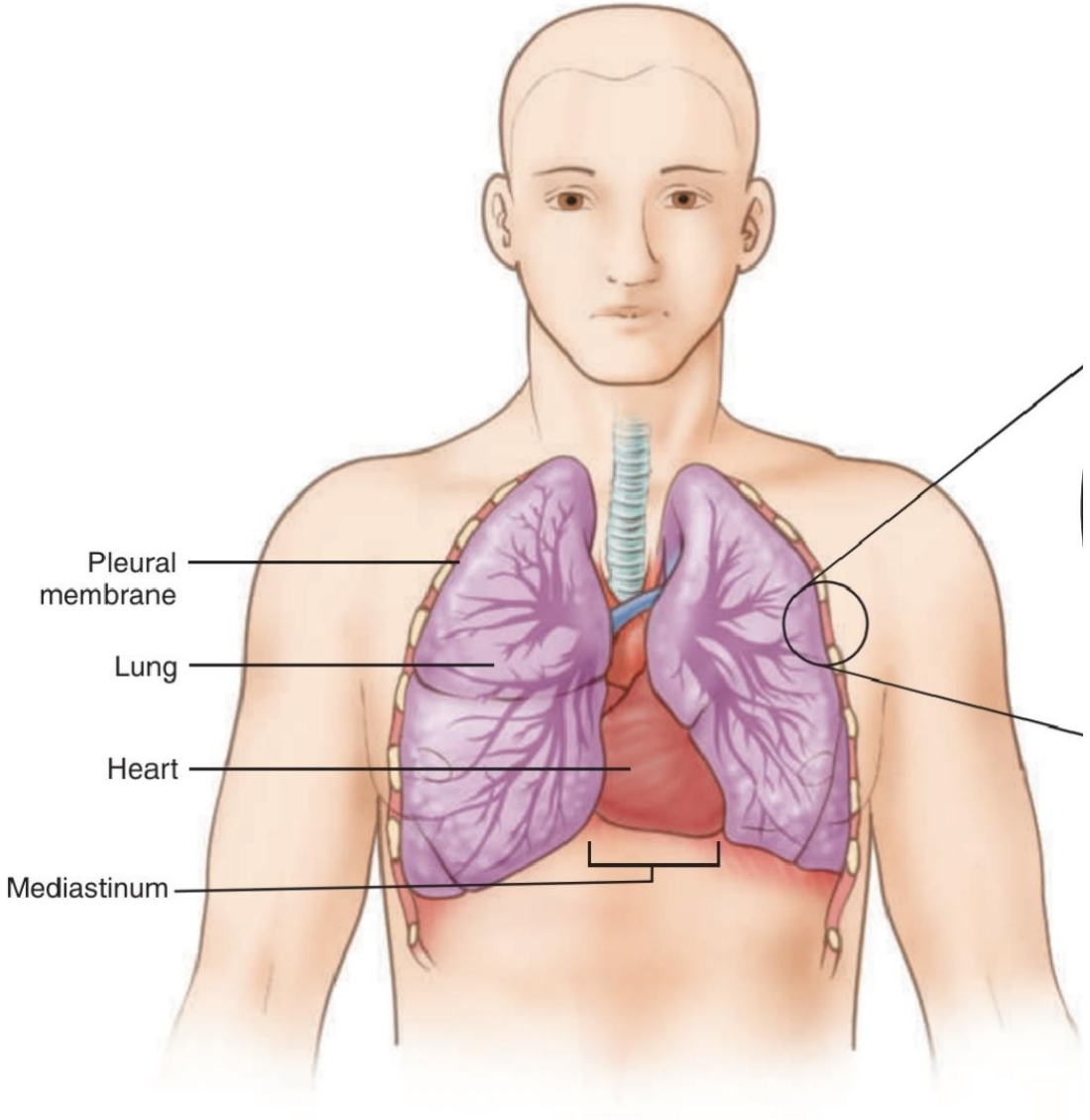
The lungs, which are the essential organs of respiration, are divided into lobes. A lobe is a subdivision or part of an organ.

- The right lung is larger and has three lobes: the upper, middle, and lower (or superior, middle, and inferior).
- The left lung has only two lobes, the upper and lower, due to space restrictions because the heart is located on that side of the body



The Mediastinum

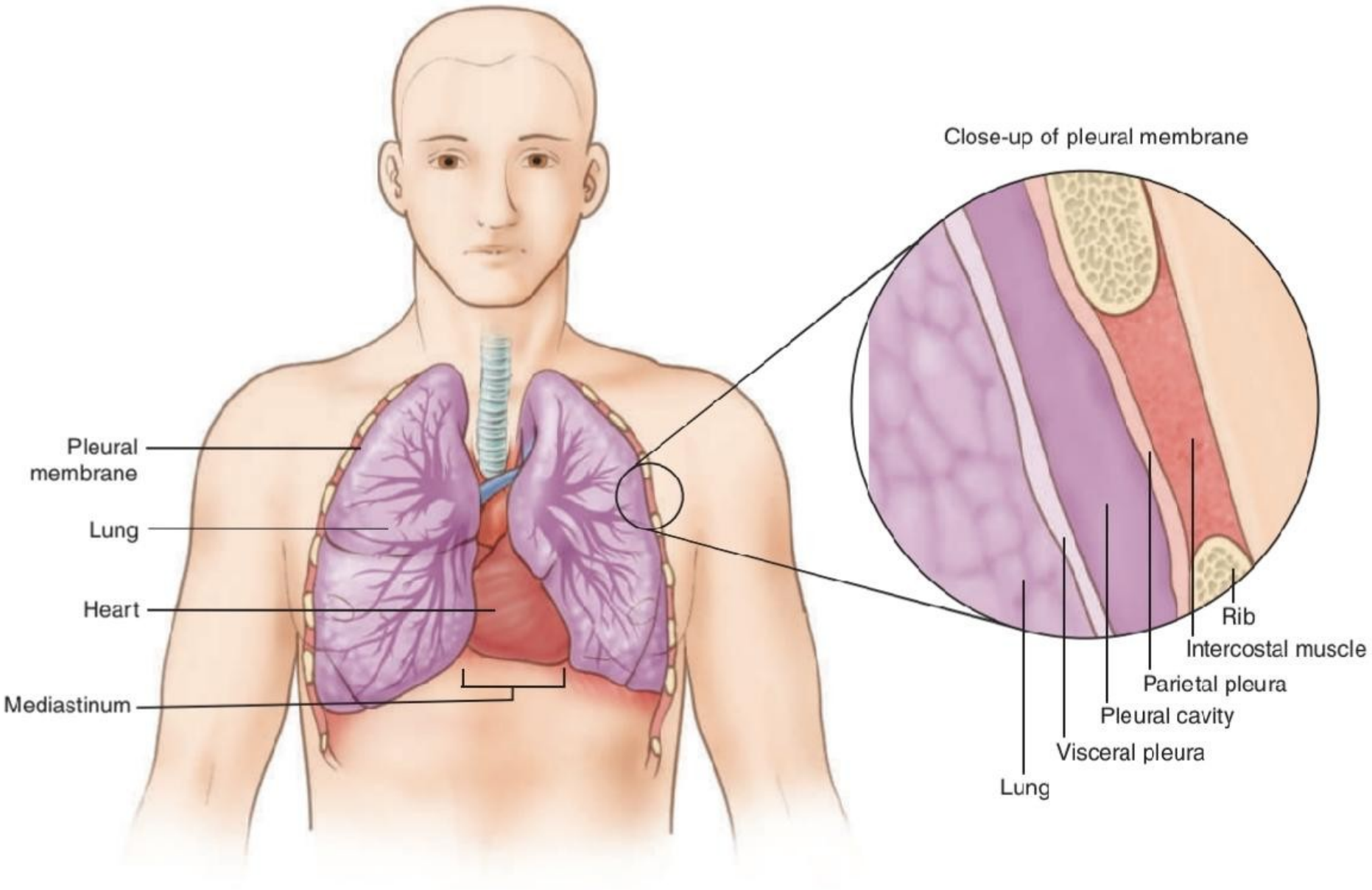
The mediastinum is the middle section of the chest cavity and is located between the lungs. This cavity contains connective tissue and organs, including the heart and its veins and arteries, the esophagus, trachea, bronchi, the thymus gland, and lymph nodes



The Pleura

The **pleura** is a thin, moist, and slippery membrane that covers the outer surface of the lungs and lines the inner surface of the thoracic cavity

- The **parietal pleura** is the outer layer of the pleura. It lines the walls of the thoracic cavity, covers the diaphragm, and forms the sac containing each lung. The parietal pleura is attached to the chest wall. *Parietal* means relating to the walls of a cavity.
- The **visceral pleura**, which is the inner layer of pleura that covers each lung, is attached directly to the lungs. *Visceral* means relating to the internal organs.
- The **pleural cavity**, also known as *the pleural space*, is the thin fluid-filled space between the parietal and visceral pleural membranes. The fluid acts as a lubricant, allowing the membranes to slide easily over each other during respiration.


Pleural membrane
Lung
Heart
Mediastinum
Close-up of pleural membrane
Rib
Intercostal muscle
Parietal pleura
Pleural cavity
Visceral pleura
Lung

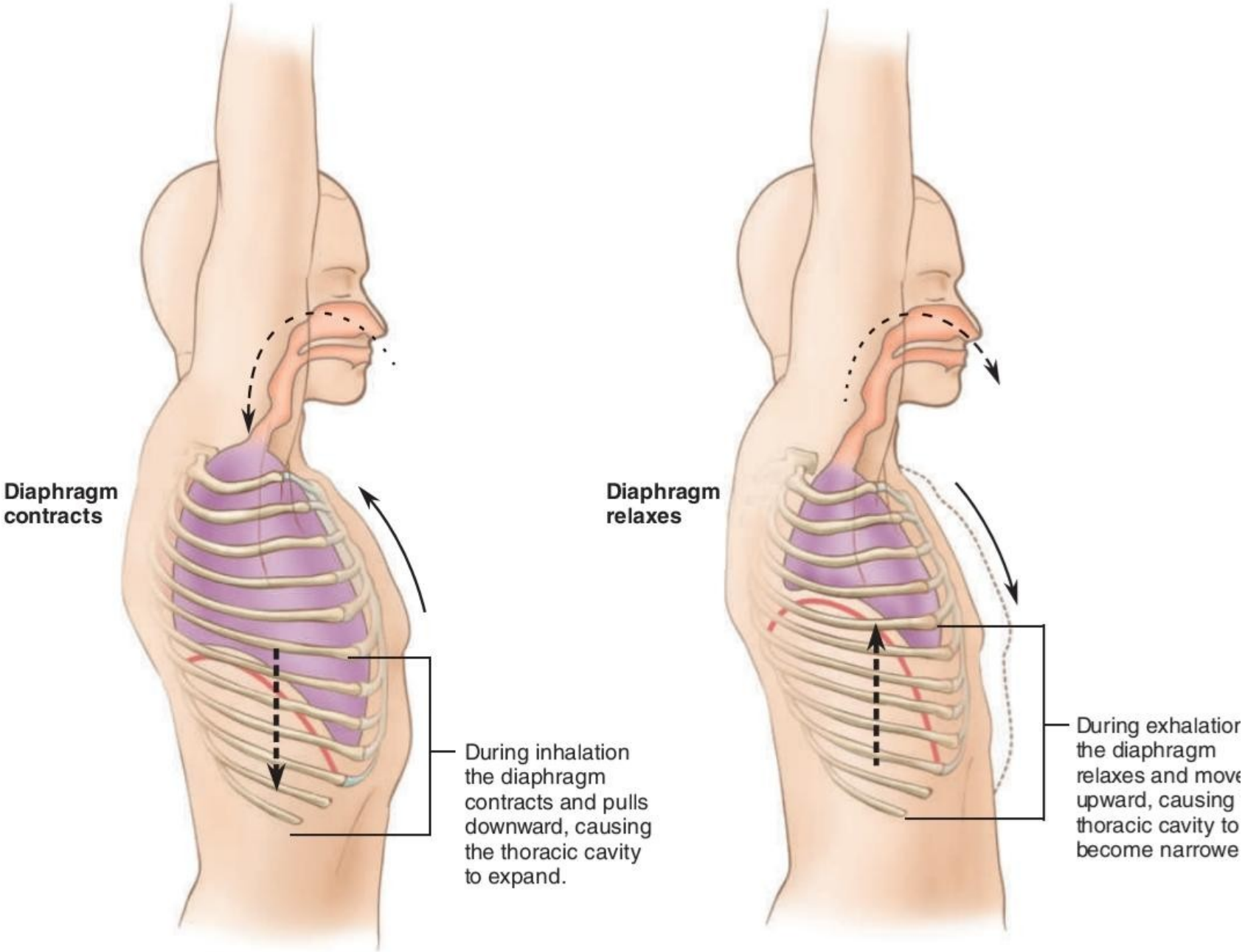
RESPIRATION

Respiration, or breathing, is the exchange of oxygen for carbon dioxide that is essential to life. A single respiration, or *breath*, consists of one inhalation and one exhalation. *Ventilation* is another word for moving air in and out of the lungs.

Inhalation and Exhalation

- **Inhalation** is the act of taking in air as the diaphragm contracts and pulls downward. This action causes the thoracic cavity to expand. This produces a vacuum within the thoracic cavity that draws air into the lungs.

Exhalation is the act of breathing out. As the diaphragm relaxes, it moves upward, causing the thoracic cavity to become narrower. This action forces air out of the lungs.



Movements of the diaphragm and thoracic cavity produce inhalation (left) and exhalation (right)

External Respiration

External respiration is the act of bringing air in and out of the lungs from the outside environment and in the process, exchanging oxygen for carbon dioxide.

- As air is inhaled into the alveoli, oxygen immediately passes into the surrounding capillaries and is carried by the erythrocytes (red blood cells) to all body cells.
- At the same time, the waste product carbon dioxide that has passed into the bloodstream is transported into the air spaces of the lungs to be exhaled.

Internal Respiration

Internal respiration, which is also known as *cellular respiration*, is the exchange of gases within the cells of the blood and tissues.

- In this process, oxygen passes from the bloodstream into the cells.
- The cells give off the waste product carbon dioxide, and this passes into the bloodstream.

MEDICAL SPECIALTIES RELATED TO THE RESPIRATORY SYSTEM

- An **otolaryngologist**, also known as an ENT (ear, nose, throat), is a physician with specialized training in the diagnosis and treatment of diseases and disorders of the head and neck.

  *(ot/o means ear, laryng/o means larynx, and -ologist means specialist)

- A **pulmonologist** is a physician who specializes in diagnosing and treating diseases and disorders of the respiratory system.

  *(pulmon means lung, and -ologist means specialist).

- A **thoracic surgeon** performs operations on the organs inside the thorax, or chest, including the heart, lungs, and esophagus

PATHOLOGY OF THE RESPIRATORY SYSTEM

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a group of lung diseases in which the bronchial airflow is obstructed, making it hard to breathe. Chronic obstructive pulmonary disease, which is most often caused by long-term smoking, is generally permanent and progressive. Most people with COPD suffer from two related conditions: chronic bronchitis and emphysema.

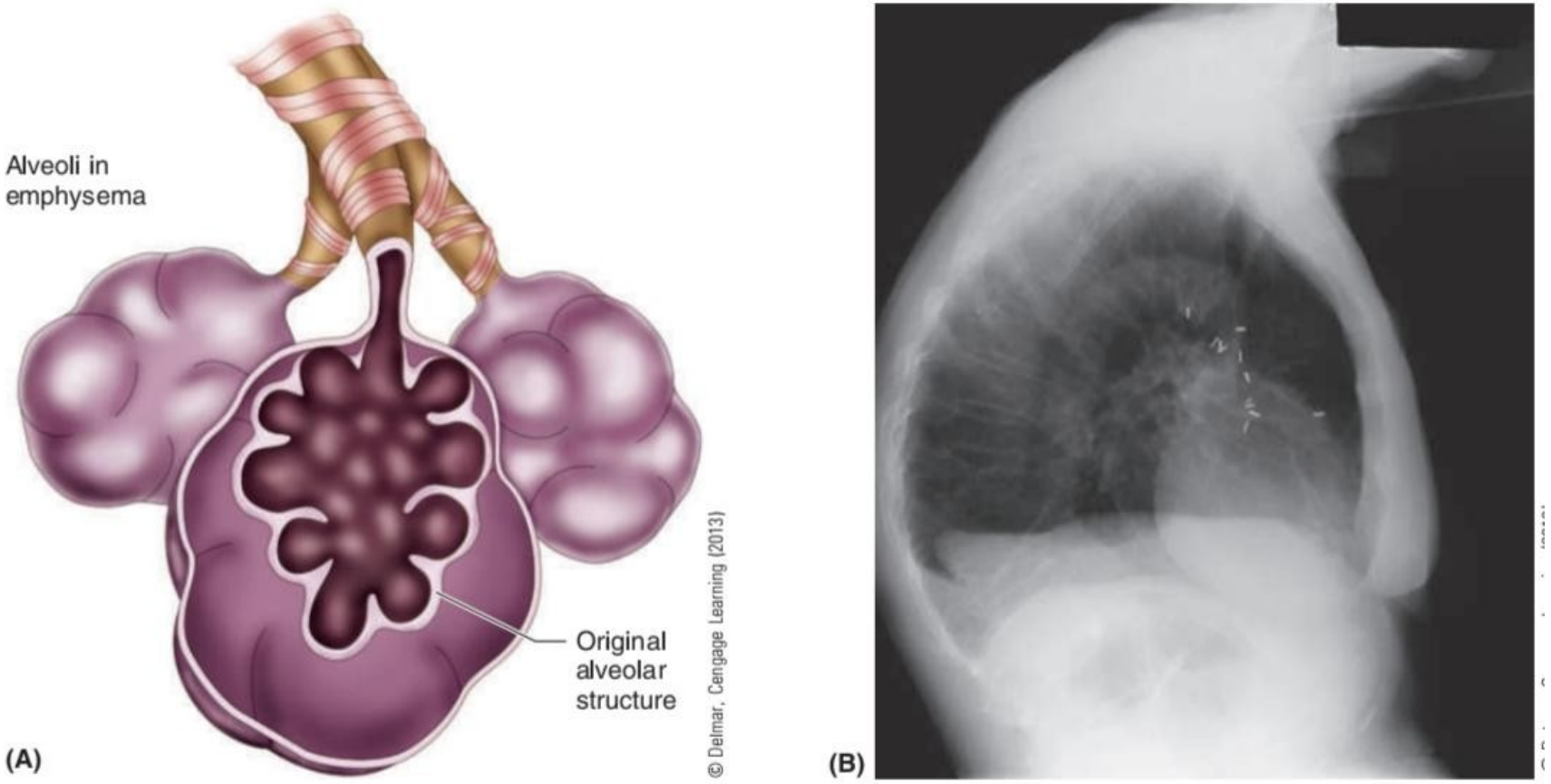
Chronic Obstructive Pulmonary Disease

Chronic Bronchitis

- Chronic bronchitis is a disease in which the airways have become inflamed due to recurrent exposure to an inhaled irritant, usually cigarette smoke. An increase in the number and size of mucus-producing cells results in excessive mucus production and a thickening of the walls of the air passages. This causes chronic coughing, difficulty getting air in and out of the lungs, and sometimes also bacterial lung infections.

Chronic Obstructive Pulmonary Disease

- ***Emphysema***
- Emphysema is the progressive, long-term loss of lung function, usually due to smoking. Emphysema is characterized by (1) a decrease in the total number of alveoli, (2) the enlargement of the remaining alveoli, and (3) the progressive destruction of the walls of these remaining alveoli.
- As the alveoli are destroyed, breathing becomes increasingly rapid, shallow, and difficult. In an effort to compensate for the loss of capacity, the lungs chronically overinflate and the rib cage stays partially expanded all the time, resulting in a slightly rounded shape called a barrel chest.



Emphysema. (A) Changes in the alveoli as the disease progresses. (B) Lateral x-ray showing lung enlargement and abnormal barrel chest in emphysema. (Note: the short white lines shown in the x-ray are surgical clips.)

Asthma

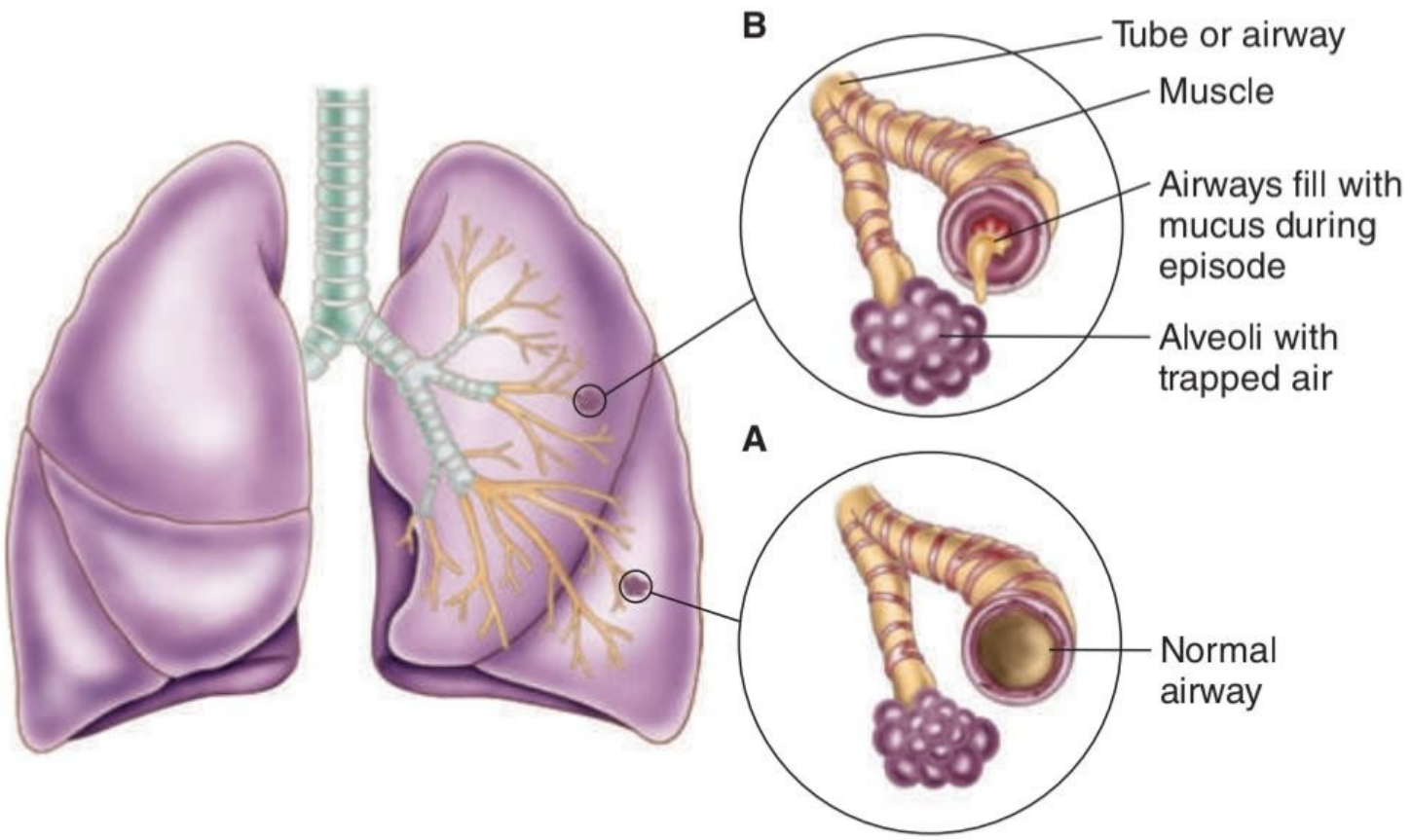
Asthma is a chronic inflammatory disease of the bronchial tubes, often triggered by an allergic reaction. Asthma is characterized by episodes of severe breathing difficulty, coughing, and wheezing. These episodes are known as *asthmatic attacks*.

Wheezing is a breathing sound caused by a partially obstructed airway. The frequency and severity of asthmatic attacks is influenced by a variety of factors, including allergens, environmental agents, exercise, and infection.

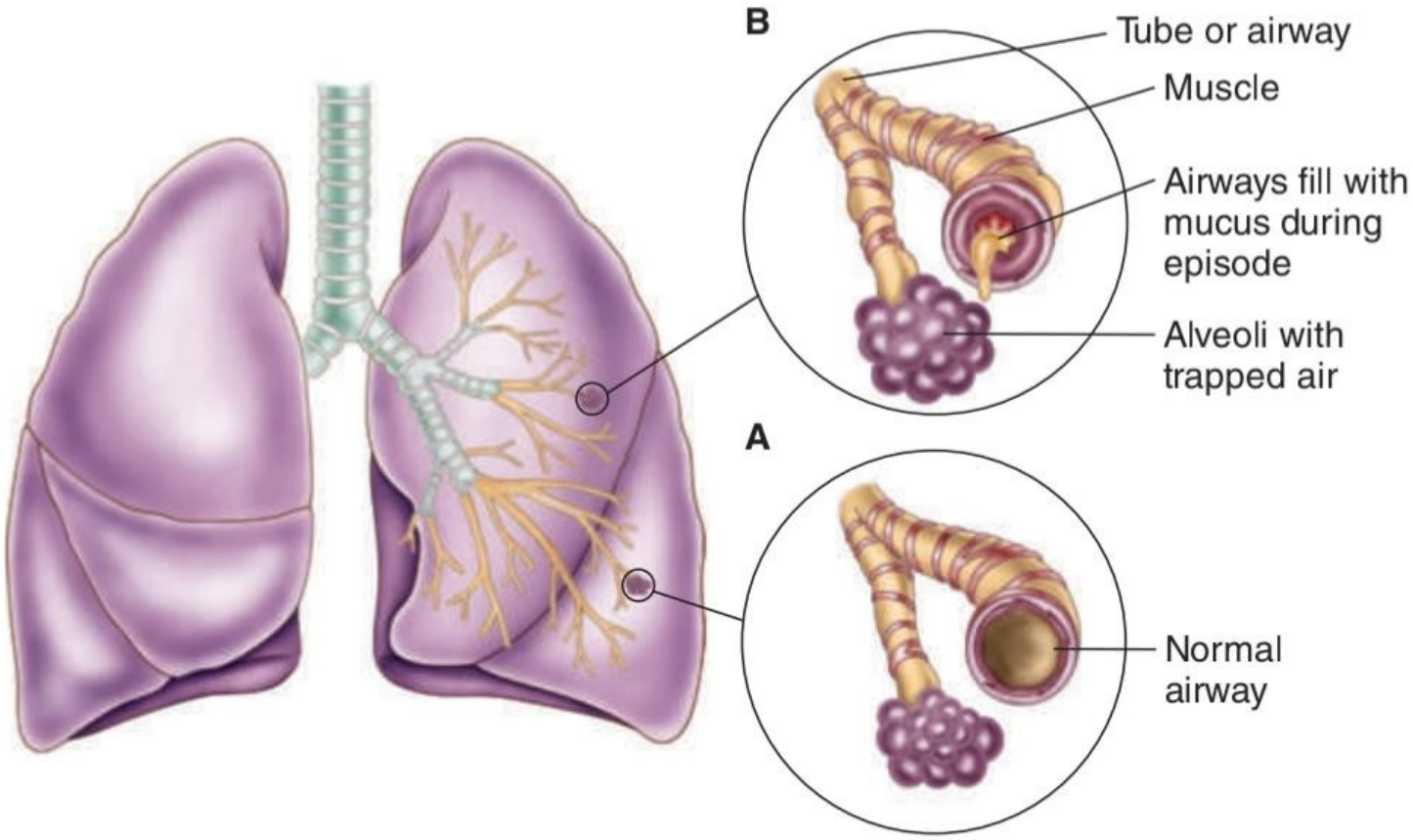
Changes in the airways during an asthma episode

(A) Before the episode, the muscles are relaxed and the airways are open.

(B) During the episode, the muscles tighten and the airways fill with mucus.



- **Airway inflammation** is the swelling and clogging of the bronchial tubes with mucus. This usually occurs after the airway has been exposed to inhaled allergens.
- A **bronchospasm** is a contraction of the smooth muscle in the walls of the bronchi and bronchioles, tightening and squeezing the airway shut
- *Exercise-induced asthma* is the narrowing of the airways that develops after 5 to 15 minutes of physical exertion. This also can be due to cold weather or allergies.
- A person who suffers from asthma is known as an *asthmatic*



UPPER RESPIRATORY DISEASES

- **Upper respiratory infections** (URI) and *acute nasopharyngitis* are among the terms used to describe the *common cold.* An upper respiratory infection can be caused by any one of 200 different viruses, the most common of which is the human rhinovirus.
- **Allergic rhinitis**, commonly referred to as an *allergy*, is an allergic reaction to airborne allergens that causes an increased flow of mucus.
- **Croup** is an acute respiratory infection in children and infants characterized by obstruction of the larynx, hoarseness, and swelling around the vocal cords resulting in a barking cough and stridor. *Stridor* is a harsh, high-pitched sound caused by a blockage present when breathing in.
- **Diphtheria** is an acute bacterial infection of the throat and upper respiratory tract. The diphtheria bacteria produce toxins that can damage the heart muscle and peripheral nerves. Through immunization the disease is now largely prevented.

UPPER RESPIRATORY DISEASES

- **Epistaxis**, also known as a *nosebleed*, is bleeding from the nose that may be caused by dry air, an injury, medication to prevent blood clotting, or high blood pressure.
- **Influenza**, also known as the *flu*, is an acute, highly contagious viral infection characterized by respiratory inflammation, fever, chills, and muscle pain. Influenza is spread by respiratory droplets and occurs most commonly in epidemics during the colder months.
- **Pertussis**, also known as *whooping cough*, is a contagious bacterial infection of the upper respiratory tract that is characterized by recurrent bouts of a paroxysmal cough, followed by breathlessness and a noisy inspiration. *Paroxysmal* means sudden or spasmlike. Childhood immunization against diphtheria, pertussis, and tetanus are given together (DPT); however, the incidence of pertussis is on the rise.
- **Rhinorrhea**, also known as a *runny nose,* is the watery flow of mucus from the nose
- **Sinusitis** is an inflammation of the sinuses.

Pharynx and Larynx

- **Pharyngitis**, also known as a *sore throat,* is an inflammation of the pharynx. It is often a symptom of a cold, flu, or sinus infection. ((pharyng means pharynx, and -itis means inflammation)
- A **laryngospasm** is the sudden spasmodic closure of the larynx (laryng/o means larynx, and -spasm means a sudden involuntary contraction). It is sometimes associated with gastroesophageal reflux disease (GERD).

Voice Disorders

- **Aphonia** is the loss of the ability of the larynx to produce normal speech sounds (a- means without, phon means sound or voice, and -ia means abnormal condition).
- **Dysphonia** is difficulty in speaking, which may include any impairment in vocal quality, including hoarseness, weakness, or the cracking of a boy’s voice during puberty.
- **Laryngitis** is an inflammation of the larynx. This term is also commonly used to describe voice loss that is caused by this inflammation (dys- means bad, phon means sound or voice, and -ia means abnormal condition).

Trachea and Bronchi

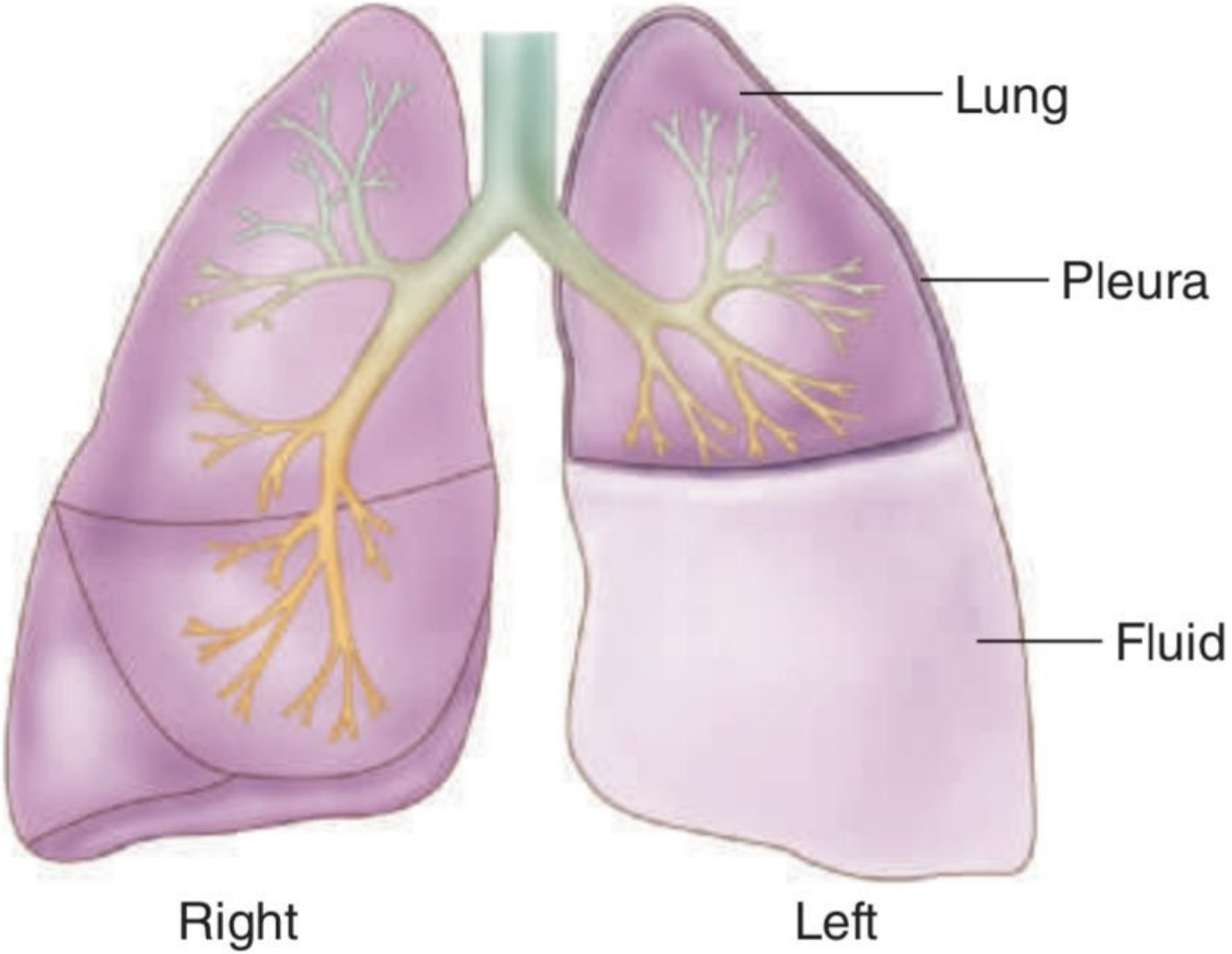
- **Tracheorrhagia** is bleeding from the mucous membranes of the trachea (trache/o means trachea, and -rrhagia means bleeding).
- **Bronchiectasis** is the permanent dilation of the bronchi, caused by chronic infection and inflammation (bronch/I means bronchus, and -ectasis means stretching or enlargement).
- **Bronchorrhea** is an excessive discharge of mucus from the bronchi (bronch/o means bronchus, and -rrhea means abnormal flow). This is often caused by chronic bronchitis or asthma.

Pleural Cavity

- **Pleurisy**, also known as pleuritis, is an inflammation of the pleura, the membranes that cover the lungs and line the pleural cavity. Pleurisy, which causes pleurodynia, may result from trauma, tuberculosis, connective tissue disease, or an infection (pleur means pleura, and -isy is a noun ending).
- **Pleurodynia** is a sharp pain that occurs when the inflamed membranes rub against each other with each inhalation (pleur/o means pleura, and -dynia means pain).
- **Pleural effusion** is the excess accumulation of fluid in the pleural space. This produces a feeling of breathlessness because it prevents the lung from fully expanding. *Effusion* is the escape of fluid from blood or lymphatic vessels into the tissues or into a body cavity.

Pleural Effusion

In pleural effusion, excess fluid in the pleural cavity prevents the lung from fully expanding.



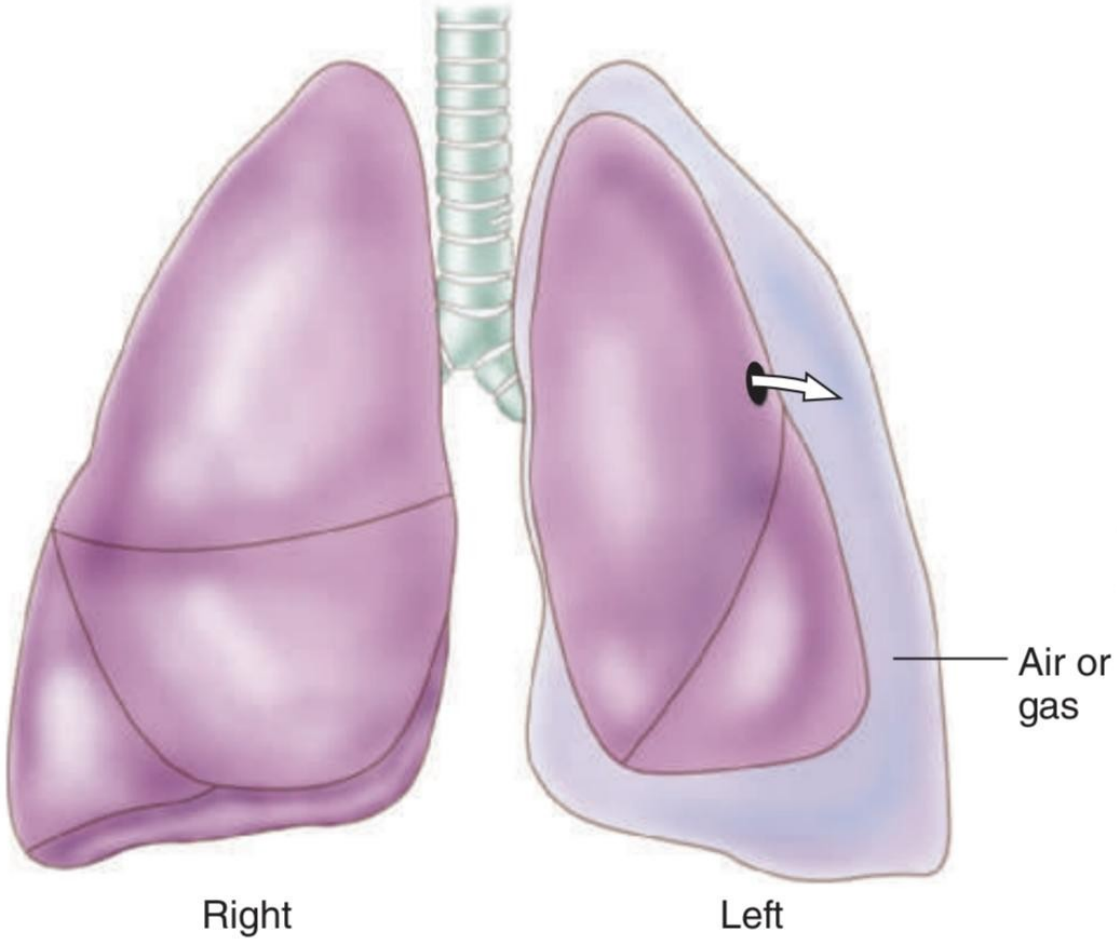
Pleural Cavity

- **Pyothorax**, also known as *empyema of the pleural cavity*, is the presence of pus in the pleural cavity between the layers of the pleural membrane (py/o means pus, and -thorax means chest).
- **Empyema** refers to a collection of pus in a body cavity.
- **Hemothorax** is a collection of blood in the pleural cavity (hem/o means blood, and -thorax means chest). This condition often results from chest trauma, such as a stab wound, or it can be caused by disease or surgery.
- A **pneumothorax** is the accumulation of air in the pleural space resulting in a pressure imbalance that causes the lung to fully or partially collapse (pneum/o means lung or air, and -thorax means chest). This can have an external cause, such as a stab wound through the chest wall, or can occur when there is a lung-disease-related rupture in the pleura that allows air to leak into

Pneumothorax

Pneumothorax is an accumulation of air or gas in the pleural space that causes the lung to collapse.

In the left lung, a perforation in the pleura allowed air to escape into the pleural space.



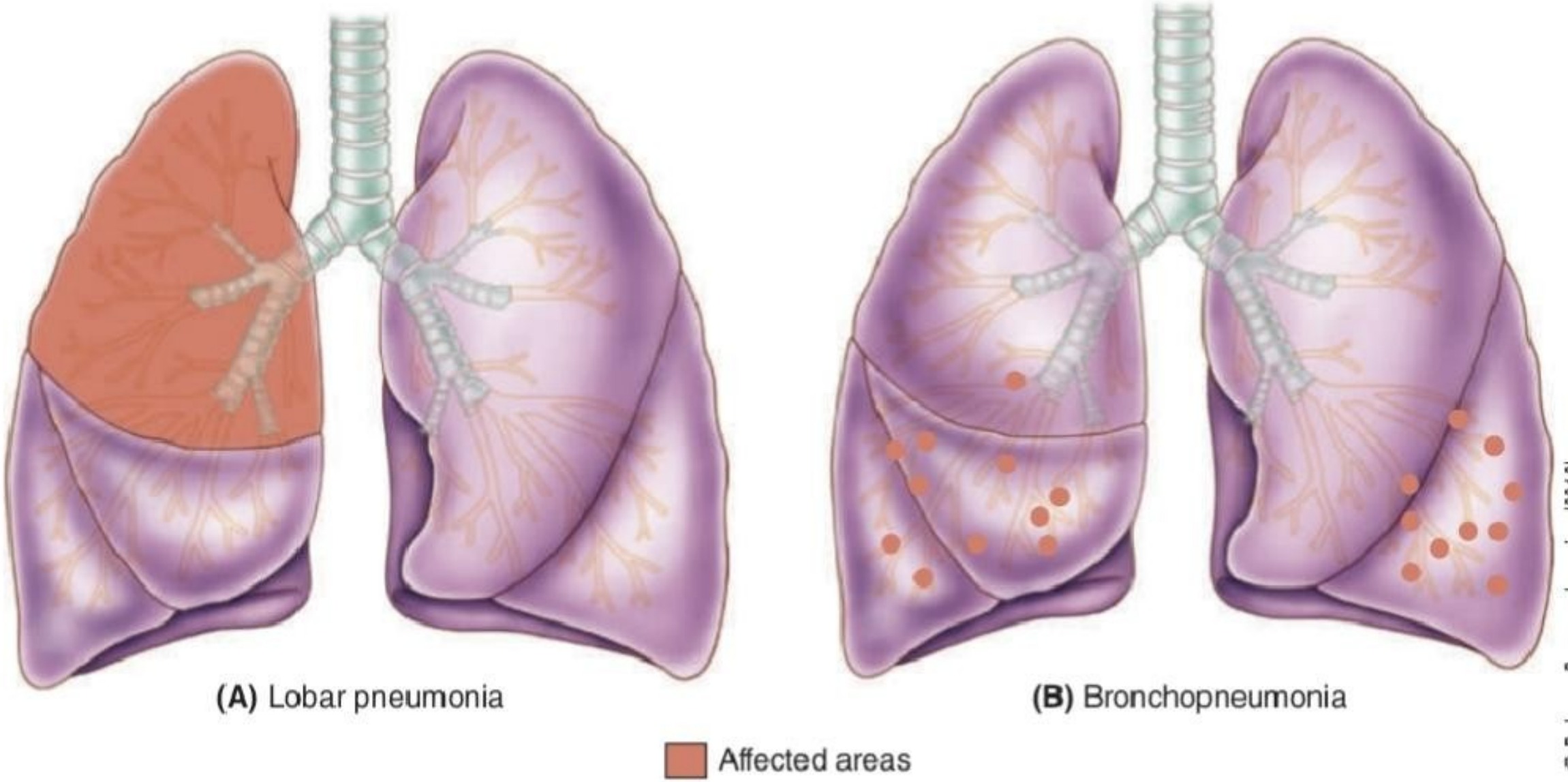
Tuberculosis

Tuberculosis (TB), which is an infectious disease caused by *Mycobacterium tuberculosis,* usually attacks the lungs; however, it can also affect other parts of the body. Pleurisy and coughing up blood (hemoptysis) can be symptoms of TB in the lungs.

- TB occurs most commonly in individuals whose immune systems are weakened by another condition such as AIDS. A healthy individual can carry latent TB without showing symptoms of the disease. Latent means present but not active.
- *Multidrug-resistant tuberculosis* is a dangerous form of tuberculosis because the germs have become resistant to the effect of the primary TB drugs.

Pneumonia Named for the Affected Lung Tissue

- **Pneumonia** is a serious inflammation of the lungs in which the alveoli and air passages fill with pus and other fluids (pneumon means lung, and -ia means abnormal condition).
- There are two types of bacterial pneumonia named for the parts of the lungs affected. These are:
- **Bronchopneumonia** is a localized form of pneumonia that often affects the bronchioles (bronch/o means bronchial tubes, pneumon means lung, and -ia means abnormal condition). Bronchopneumonia often leads to lobar pneumonia.
- **Lobar pneumonia** affects larger areas of the lungs, often including one or more sections, or lobes, of a lung. *Double pneumonia* is lobar pneumonia involving both lungs and is usually a form of bacterial pneumonia.


(A) Lobar pneumonia
(B) Bronchopneumonia
Affected areas

Pneumonia Named for the Causative

The most common causative agents are air pollution, bacteria, fungi, viruses, and inhaled liquid or chemicals.

- **Aspiration pneumonia** can occur when a foreign substance, such as vomit, is inhaled into the lungs. As used here, aspiration means inhaling or drawing a foreign substance into the upper respiratory tract.
- **Bacterial pneumonia** is most commonly caused by *Streptococcus pneumoniae*. *Pneumococcal pneumonia* is the only form of pneumonia that can be prevented through vaccination.
- **Community-acquired pneumonia** is a type of pneumonia that results from contagious infection outside of a hospital or clinic.
- **Hospital-acquired pneumonia**, or *nosocomial pneumonia*, is a type of pneumonia contracted during a stay in the hospital when a patient’s defenses are impaired. Patients on a respirator are particularly at risk. Nosocomial means hospital-acquired.

Pneumonia Named for the Causative

- **Walking pneumonia**, also known as *mycoplasma pneumonia*, is a milder but longer-lasting form of the disease caused by the bacteria *Mycoplasma pneumoniae.* It gets its name from the fact that the patient is often not bedridden.
- **Pneumocystis pneumonia** is an opportunistic infection caused by the yeast-like fungus *Pneumocystis carinii*.
- **Viral pneumonia**, which can be caused by several different types of viruses, accounts for approximately a third of all pneumonias.

Interstitial Lung Disease

Interstitial lung disease refers to a group of almost 200 disorders that cause inflammation and scarring of the alveoli and their supporting structures. Interstitial means relating to spaces within or around a tissue or an organ. In these lung conditions the tissue around the alveoli becomes scarred or stiff, leading to a reduction of oxygen being transferred to the blood.

- **Pulmonary fibrosis**, or interstitial fibrosis, is the progressive formation of scar tissue in the lung, resulting in decreased lung capacity and increased difficulty in breathing (fibros means fibrous connective tissue, and -is is the noun ending). *Fibrosis* is a condition in which normal tissue is replaced by fibrotic (hardened) tissue.

Environmental and Occupational Interstitial Lung Diseases

- **Pneumoconiosis** is any fibrosis of the lung tissues caused by dust in the lungs after prolonged environmental or occupational contact (pneum/o means lung, coni means dust, and -osis means abnormal condition or disease).

- **Anthracosis**, also known as coal miner’s pneumoconiosis or black lung disease, is caused by coal dust in the lungs (anthrac means coal dust, and -osis means abnormal condition or disease).

- **Asbestosis** is caused by asbestos particles in the lungs and usually occurs after working with asbestos (asbest means asbestos, and -osis means abnormal condition or disease).

- **Silicosis** is caused by inhaling silica dust in the lungs and usually occurs after working in occupations including foundry work, quarrying, ceramics, glasswork, and sandblasting (silic means glass, and -osis means abnormal condition or disease).

Cystic Fibrosis

Cystic fibrosis is a life-threatening genetic disorder in which the lungs and pancreas are clogged with large quantities of abnormally thick mucus. This results in damage to the lungs, poor growth, and nutritional deficiencies. Treatments for cystic fibrosis include:

- Pancreatic enzymes to aid the digestive system
- Antibiotics to prevent and treat lung infections
- Bronchodilators to keep airways open
- Chest percussion, which is a therapeutic technique to remove excess mucus from the lungs. This is often performed with the patient positioned at an angle to allow gravity to help drain the secretions.

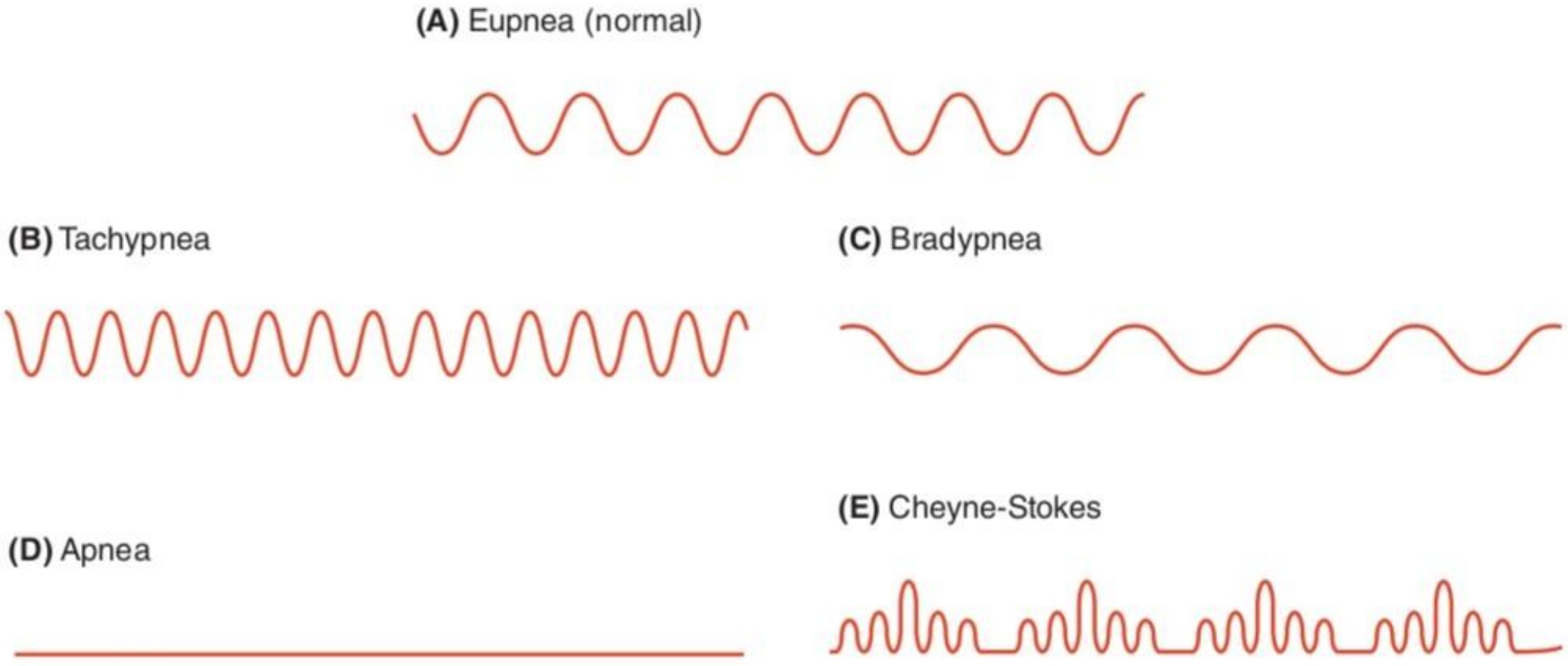
Lung Cancer

Lung cancer is a condition in which cancer cells form in the tissues of the lung. Important risk factors for lung cancer are smoking and inhaling secondhand smoke.

Breathing Disorders

The general term breathing disorders describes abnormal changes in the rate or depth of breathing. Specific terms describe in greater detail the changes that are occurring.

- **Eupnea** is easy or normal breathing (eu- means good, and -pnea means breathing). This is the baseline for judging some breathing disorders. Eupnea is the opposite of apnea.
- **Apnea** is the temporary absence of spontaneous respiration (a- means without, and -pnea means breathing). It is a common respiratory problem in premature infants. Apnea is the opposite of eupnea.
- **Bradypnea** is an abnormally slow rate of respiration, usually of less than 10 breaths per minute (brady- means slow, and -pnea means breathing). Bradypnea is the opposite of tachypnea.
- **Cheyne-Stokes respiration** is an irregular pattern of breathing characterized by alternating rapid or shallow respiration followed by slower respiration or apnea. This pattern sometimes occurs in comatose patients or those nearing death.


(A) Eupnea (normal)
(B) Tachypnea
(C) Bradypnea
(D) Apnea
(E) Cheyne-Stokes

Breathing Disorders

- **Tachypnea** is an abnormally rapid rate of respiration usually of more than 20 breaths per minute (tachy- means rapid, and -pnea means breathing). Tachypnea is the opposite of bradypnea.
- **Dyspnea**, also known as *shortness of breath (SOB)*, is difficult or labored breathing (dys means painful, and -pnea means breathing). Shortness of breath is frequently one of the first symptoms of heart failure. It can also be caused by strenuous physical exertion or can be due to lung damage that produces dyspnea even at rest.
- **Hyperpnea**, which is commonly associated with exertion, is breathing that is deeper and more rapid than is normal at rest (hyper- means excessive, and -pnea means breathing). Hyperpnea may also occur at high altitude, or be caused by anemia or sepsis. Hyperpnea is the opposite of hypopnea.
- **Hypopnea** is shallow or slow respiration (hypo- means decreased, and -pnea means breathing). Hypopnea is the opposite of hyperpnea.
- **Hyperventilation** is an abnormally rapid rate of deep respiration that is usually associated with anxiety (hyper- means excessive, and -ventilation means breathing). This decreases the level of carbon dioxide in the blood, causing dizziness and tingling in the fingers and toes.

Sleep-Related Breathing Disorders

Sleep related breathing disorders are characterized by disruptions of normal breathing patterns that only occur during sleep and are associated with higher risks of cardiovascular disease and strokes.

- **Sleep apnea** is a potentially serious disorder in which breathing repeatedly stops and starts during sleep for long-enough periods to cause a measurable decrease in blood oxygen levels. *Obstructive sleep apnea* is caused by the muscles at the back of the throat relaxing and narrowing the airways.
- *Snoring*, which can be a symptom of sleep apnea, is noisy breathing caused by vibration of the soft palate.

Coughing

- **Expectoration** is the act of coughing up and spitting out saliva, mucus, or other body fluid (expector/o means to cough up, and -ation means state or action).
- **Hemoptysis** is the expectoration of blood or blood-stained sputum derived from the lungs or bronchial tubes as the result of a pulmonary or bronchial hemorrhage (hem/o means blood, and -ptysis means spitting).

Lack of Oxygen

- **Airway obstruction**, commonly known as *choking*, occurs when food or a foreign object partially or completely blocks the airway and prevents air from entering or leaving the lungs. This can be a life-threatening emergency requiring immediate action through the performance of the *abdominal thrust maneuver.* This is also known as the *Heimlich maneuver.*
- **Anoxia** is the absence of oxygen from the body's tissues and organs even though there is an adequate flow of blood (an- means without, ox means oxygen, and -ia means abnormal condition). If anoxia continues for more than 4 to 6 minutes, irreversible brain damage can occur.
- **Hypoxia** is the condition of having deficient oxygen levels in the body's tissues and organs; however, it is less severe than anoxia (hyp means deficient, ox means oxygen, and -ia means abnormal condition). This condition can be caused by a variety of factors, including head trauma, carbon monoxide poisoning, suffocation, and high altitudes.

Lack of Oxygen

- *Altitude hypoxia*, also known as *altitude sickness*, is a condition that can be brought on by the decreased oxygen in the air at higher altitudes, usually above 8,000 feet.
- **Asphyxia** is the loss of consciousness that occurs when the body cannot get the oxygen it needs to function. Asphyxia can be caused by choking, suffocation, drowning, or inhaling gases such as carbon monoxide.
- *Asphyxiation* is a state of asphyxia or suffocation. In this life-threatening condition, oxygen levels in the blood drop quickly, carbon dioxide levels rise, and unless the patient’s breathing is restored within a few minutes, death or serious brain damage follows.
- **Cyanosis** is a bluish discoloration of the skin and mucous membranes caused by a lack of adequate oxygen in the blood

Lack of Oxygen

- **Hypercapnia** is the abnormal buildup of carbon dioxide in the blood (hyper- means excessive, capn means carbon dioxide, and -ia means abnormal condition).
- **Hypoxemia** is the condition of having low oxygen levels in the blood, usually due to respiratory disorders or heart conditions (hyp means deficient, ox means oxygen, and -emia means blood).
- **Respiratory failure** (RF), also known as *respiratory acidosis*, is a condition in which the level of oxygen in the blood becomes dangerously low (hypoxemia) or the level of carbon dioxide becomes dangerously high (hypercapnia). It is a medical emergency that can result from a chronic condition or develop suddenly.
- **Smoke inhalation** is damage to the lungs in which particles

Sudden Infant Death Syndrome

Sudden infant death syndrome (SIDS) is the sudden and unexplainable death of an apparently healthy sleeping infant between the ages of 2 months and 6 months. Although the cause of SIDS is still unknown, it is suspected to be a heart problem or interruption in breathing.

The recommendation that infants sleep on their back or side instead of facedown has reduced the incidence of SIDS.

DIAGNOSTIC PROCEDURES OF THE RESPIRATORY SYSTEM

- The *respiratory rate* is a count of the number of breaths (one inhalation and one exhalation) per minute.
- *Respiratory sounds* such as rale, rhonchi, and stridor provide information about the condition of the lungs and pleura.
- **Bronchoscopy** is the visual examination of the bronchi using a bronchoscope (bronch/o means bronchus, and -scopy means direct visual examination). A *bronchoscope* is a flexible, fiber-optic device that is passed through the nose or mouth and down the airways. It can also be used for operative procedures, such as tissue repair or the removal of a foreign object.
- A **chest x-ray** (CXR), also known as *chest imaging*, is a valuable tool for diagnosing pneumonia, lung cancer, pneumothorax, pleural effusion, tuberculosis, and emphysema.

DIAGNOSTIC PROCEDURES OF THE RESPIRATORY SYSTEM

- **Laryngoscopy** is the visual examination of the larynx and vocal cords using a flexible or rigid laryngoscope inserted through the mouth (laryng/o means larynx, and -scopy means a direct visual examination). *Indirect laryngoscopy* is a simpler version of this test in which the larynx is viewed by shining a light on an angled mirror held at the back of the soft palate.
- A **peak flow meter** is an inexpensive handheld device used to let patients with asthma measure air flowing out of the lungs, revealing any narrowing of the airways in advance of an asthma attack.
- **Polysomnography**, also known as a *sleep study*, measures physiological activity during sleep and is often performed to detect nocturnal defects in breathing associated with sleep apnea (poly- means many, somn/o means sleep, and -graphy means the process of recording).

DIAGNOSTIC PROCEDURES OF THE RESPIRATORY SYSTEM

- **Pulmonary function tests** (PFTs) are a group of tests that measure volume and flow of air by using a spirometer. These tests are measured against a norm for the individual’s age, height, and sex
- A **spirometer** is a recording device that measures the amount of air inhaled or exhaled (volume) and the length of time required for each breath (spir/omeans to breathe, and -meter means to measure).
- A **pulse oximeter** is an external monitor placed on the patient’s fingertip or earlobe to measure the oxygen saturation level in the blood (ox/l means oxygen, and -meter means to measure). This is a noninvasive method of assessing basic respiratory function.
- **Phlegm** is thick mucus secreted by the tissues lining the respiratory passages.
- **Sputum** is phlegm ejected through the mouth that can be examined for diagnostic purposes. *Sputum cytology* is a procedure in which a sample of mucus is coughed up from the lungs and then examined under a microscope to detect cancer cells.

Tuberculosis Testing

Two kinds of tests can be used to help detect tuberculosis infection: tuberculin skin testing and blood tests. These tests show whether the patient is infected with TB; however, they do not show whether the infection is latent or active.

- **Tuberculin skin testing** is a screening test for tuberculosis in which the skin of the arm is injected with a harmless antigen extracted from TB bacteria. The *tuberculin tine test* is performed using an instrument with several small prongs called tines.
- The **Mantoux PPD skin test** is considered a more accurate skin test for diagnosing tuberculosis. A very small amount of PPD tuberculin (a purified protein derivative) is injected just under the top layer of the skin on the forearm. The site is checked for a reaction 48 to 72 hours later.
- A positive result indicates the possibility of exposure to the

TREATMENT PROCEDURES OF THE RESPIRATORY SYSTEM

Medications and Their Administration

- An **antitussive**, commonly known as *cough medicine*, is administered to prevent or relieve coughing (anti- means against, tuss means cough, and -ive means performs).
- A **bronchodilator** is a medication that relaxes and expands the bronchial passages into the lungs. Patients with asthma use short-acting bronchodilators as needed as rescue medications, while long-acting bronchodilators are used every day to control the condition.
- A **metered-dose inhaler** (MDI) administers aspecific amount of a medication such as a bronchodilator in aerosol form. A gas propellant mixes with the medicine to push it into the lungs.
- A **nebulizer** is an electronic device that pumps air or oxygen through a liquid medicine to turn it into a mist, which is then inhaled by the patient via a face mask or mouthpiece.

TREATMENT PROCEDURES OF THE RESPIRATORY SYSTEM

Asthma Treatment

- The goal of asthma treatment is to avoid the substances that trigger symptoms and to control airway inflammation. Most people with asthma take two kinds of medicines.
- *Controller medicines*, such as inhaled corticosteroids, are long-acting medications taken daily to prevent attacks. These medications help control inflammation and stop the airways from reacting to the factors that trigger the asthma.
- *Quick-relief*, or *rescue,* medicines, are taken at the first sign of an attack to dilate the airways and make breathing easier. These medications are known as bronchodilators and are discussed under medications. Corticosteroids may also be given intravenously during a severe attack.

TREATMENT PROCEDURES OF THE RESPIRATORY SYSTEM

The Nose, Throat, and Larynx

- **Endotracheal intubation** (ETT) is the passage of a tube through the mouth into the trachea to establish or maintain an open airway, especially when a patient is on a ventilator (endo- means within, trache means trachea, and -al means pertaining to). Intubation is the insertion of a tube, usually for the passage of air or fluids.
- **Functional endoscopic sinus surgery** (FESS) is a procedure performed using an endoscope in which chronic sinusitis is treated by enlarging the opening between the nose and sinus.
- A **laryngectomy** is the surgical removal of the larynx (laryng means larynx, and -ectomy means surgical removal).
- A **laryngotomy** is a surgical incision into the larynx, performed when the upper part of the airway is obstructed (laryng means larynx, and -otomy means surgical incision).
- **Septoplasty** is the surgical repair or alteration of parts of the nasal septum (sept/o means septum, and -plasty means surgical repair).

TREATMENT PROCEDURES OF THE RESPIRATORY SYSTEM

The Trachea

- **Tracheostomy** is the surgical creation of a stoma into the trachea to insert a temporary or permanent tube to facilitate breathing (trache means trachea, and -ostomy means surgically creating an opening). The term tracheostomy is used to refer to the surgical procedure and to the stoma itself. As used here, a stoma means a surgically created opening on a body surface.
- An emergency **tracheotomy** is a procedure in which an incision is made into the trachea to gain access to the airway below a blockage (trache means trachea, and -otomy means surgical incision).

TREATMENT PROCEDURES OF THE RESPIRATORY SYSTEM

The Lungs, Pleura, and Thorax

- A **pneumonectomy** is the surgical removal of all or part of a lung (pneumon means lung, and -ectomy means surgical removal).
- A **lobectomy** is the surgical removal of a lobe of an organ, usually the lung, brain, or liver (lob means lobe, and -ectomy means surgical removal).
- **Wedge resection** is a surgery in which a small wedge-shaped piece of cancerous lung tissue is removed, along with a margin of healthy tissue around the cancer.
- **Thoracentesis** is the surgical puncture of the chest wall with a needle to obtain fluid from the pleural cavity (thor/a means thorax or chest, and -centesis means surgical puncture to remove fluid). This procedure is performed to remove liquid (pleural effusion) or air (pneumothorax) from the pleural cavity.

TREATMENT PROCEDURES OF THE RESPIRATORY SYSTEM

The Lungs, Pleura, and Thorax

- A **thoracotomy** is a surgical incision into the chest walls to open the pleural cavityfor biopsy or treatment (thorac means chest, and -otomy means surgical incision). A thoracotomy is used to gain access to the lungs, heart, esophagus, diaphragm, and other organs.
- **Video-assisted thoracic surgery** (VATS) is the use of a thoracoscope to view the inside of the pleural cavity through very small incisions. A *thoracoscope* is a specialized endoscope used for treating the thorax. This procedure is used to remove small sections of cancerous tissue and to obtain biopsy specimens to diagnose certain types of pneumonia, infections, or tumors of the chest wall. It is also used to treat repeatedly collapsing lungs.

Respiratory Therapy

- **Diaphragmatic breathing**, also known as *abdominal breathing*, is a relaxation technique used to relieve anxiety.
- A **CPAP machine** (continuous positive airway pressure) is a noninvasive ventilation device used in the treatment of sleep apnea. A face mask is connected to a pump that creates constant air pressure in the nasal passages, holding the airway open. Although this does not cure sleep apnea, it does reduce snoring and prevents dangerous apnea disturbances.
- A **BiPAP machine** (bilevel positive airway pressure) is like a CPAP machine; however, it can be set at a higher pressure for inhaling and a lower pressure for exhaling. It is used for sleep apnea in patients with neuromuscular diseases or those who find the CPAP machine uncomfortable.

Respiratory Therapy

- An **Ambu bag**, or *bag valve mask*, is an emergency resuscitator used to assist ventilation. A flexible air chamber is squeezed to force air through a face mask into the lungs of the patient, a process referred to as “bagging.”
- A **ventilator**, also called a *respirator,* is a mechanical device for artificial respiration that is used to replace or supplement the patient’s natural breathing function. The ventilator forces air into the lungs; exhalation takes place passively as the lungs contract.

Supplemental Oxygen Therapy

Supplemental oxygen is administered when the patient is unable to maintain an adequate oxygen saturation level in the blood from breathing normal air. Oxygen is administered by using a compressor either flowing into a hood or tent, or delivered directly to the patient using one of the following devices:

- *A nasal cannula* is a small tube that divides into two nasal prongs.
- A *rebreather mask* allows the exhaled breath to be partially reused, delivering up to 60% oxygen.
- A non-rebreather mask allows higher levels of oxygen to be added to the air taken in by the patient.

Supplemental Oxygen Therapy

Hyperbaric oxygen therapy (HBOT) involves breathing pure oxygen in a special chamber that allows air pressure to be raised up to three times higher than normal. The lungs and the bloodstream are thus able to absorb more oxygen, which is delivered throughout the body to promote healing and fight infection.